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Draft Environmental Impacts/Consequences

Bay-Delta Hydrodynamics and Riverine Hydraulics

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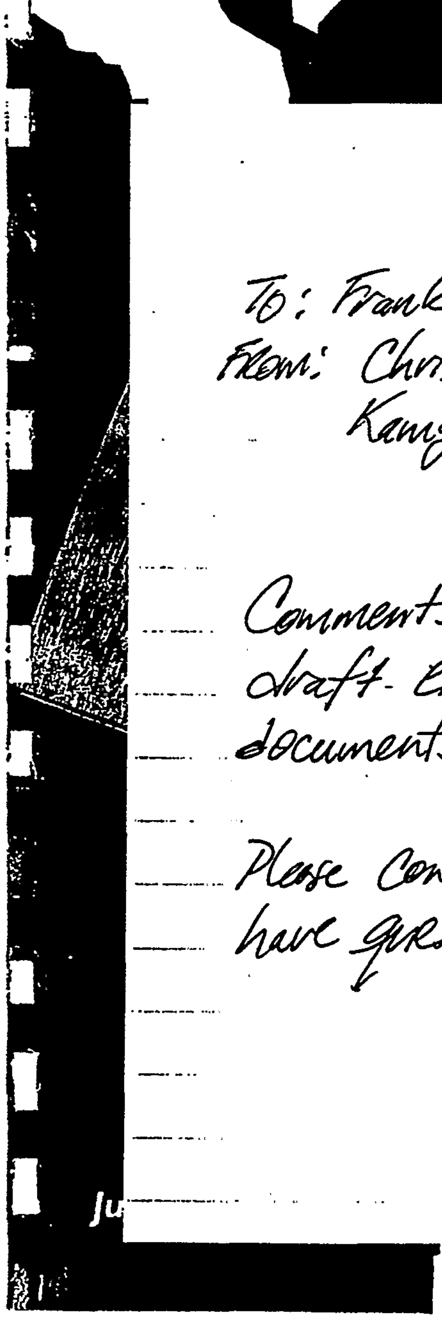
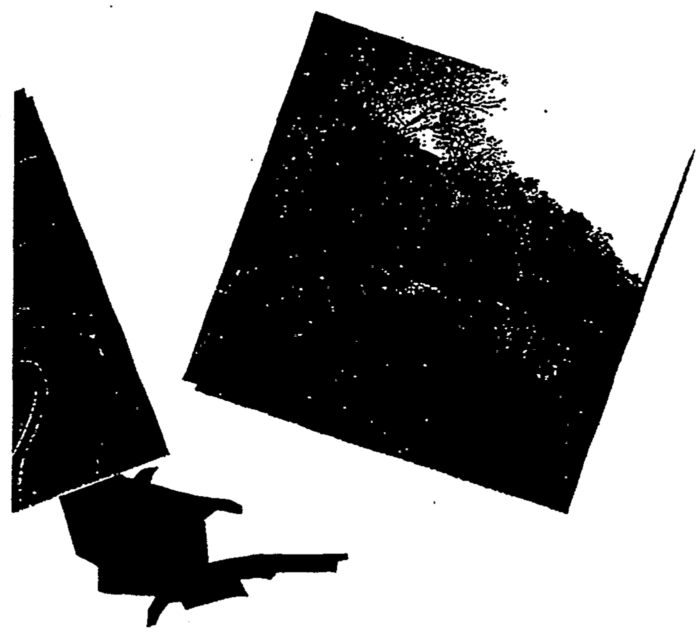
Comments on July 1, 1997 draft environmental documents on hydrodynamics.

Please contact us if you have questions.





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2.2 Summary of Mitigation Strategies

The potential impacts discussed in this document are based on computer model simulations of programmatic alternatives. As the planning process progresses, the model simulations will be refined. As site-specific alternatives emerge, even more detailed design and analysis information will become available. FOR EXAMPLE, ~~If~~ Alternative 3 is selected for further analysis and design, it may be possible to develop specific mitigation strategies to avoid potentially significant low flow and associated salinity problems in the south Delta. In general, it is expected that mitigation will include revised operating scenarios to reduce water quality problems that may occur during low flow conditions. X

2.3 Summary of Potentially Significant Unavoidable Impacts

The impacts that have the greatest potential to be significant are the simulated reductions of low flows in the south Delta area, primarily associated with Alternative 3. As mentioned above, if Alternative 3 is selected for further analysis and design, it may be possible to develop specific mitigation strategies for these problems. In general, it is expected that mitigation will include revised operating scenarios to reduce water quality problems that may occur during low flow conditions.

The isolated facility in Alternative 3 reduces the amount of fresh water entering the Delta from the Sacramento River via the Delta Cross Channel and flowing to the export pumps at Clifton Court Forebay. Without the flushing effects of fresh water from the Sacramento River, salts tend to build up in the southern Delta. Increases also were seen in the central Delta (analyzed at Jersey Point), although not as significantly as in the south.

III. ASSESSMENT METHODS

3.1 Delta Region

Hydrodynamic impacts of the alternatives on the Delta are evaluated based on the following: 1) Effects on MONTHLY AVERAGE flows, velocities, and stages in Delta channels; 2) Changes in the fate of mass ~~injected~~ released at particular locations within the Delta; 3) Effects on monthly average net Delta outflow; 4) Effects on central Delta monthly average outflow; 5) Changes to the X2 location; and 6) Changes in monthly average salinity. The program-level analysis of potential hydrodynamic changes in the Delta for items 1, 2, 4, and 6 focuses on changes to the Delta that may result from modifications within the Delta itself, using the Delta simulation computer model (DWRDSM1). Items 3 and 5 were evaluated using the operations planning model ~~river simulation model~~ (DWRSIM) and focuses on changes in conveyance and storage. Specifics of the DWRSIM modeling effort are discussed in Section 3.3. not "river" X

DWRDSM1 was run for the alternative configurations identified in Table 3.1-1 (specific information about the modeling effort can be found in __). These configurations represent the range of in-Delta modifications that are being considered in this programmatic analysis. DWRDSM1 was applied to the Delta using 16 years of monthly average hydrologic data (October 1975 to

September 1991). Input monthly stream flows for the 16 years were first determined using DWRSIM.

Within each alternative, configurations could be affected by changes in the available storage, which were not modeled in the DWRDSM1 modeling effort. Such changes could affect the total Delta inflow for any given period and, hence, could change the magnitude of flows within the Delta. These changes can be understood by comparing two different inflow conditions within the 16-year record evaluated in the DWRDSM1 modeling analysis.

The strategy to analyze hydrodynamic conditions within the Delta can be summarized as follows:

1. Analyze changes in hydrodynamic conditions resulting from modifications in the Delta for appropriate alternative configurations using the DWRDSM1 model with a 16-year monthly average inflow record. The inflow record is equivalent to No Action Alternative with regard to alternative storage configurations (i.e., storage was not included).
2. Use DWRSIM to evaluate Delta inflow changes associated with alternative storage configurations. Then, estimate the response for each Delta configuration using the 16-year record using DWRDSM1. For example, if a particular storage configuration were to reduce total Delta inflow by two percent, then from within the 16-year record, flow conditions could be compared for inflows that differed by two percent.

It's not terribly clear that the 16-year monthly avg hydrology comes from DWRSIM

The model results for the first phase of the analysis are summarized in this document in quantitative tables and figures. The second phase of the analysis is discussed in more qualitative terms.

In order to determine effects of the alternatives on flows, velocities, and stages, three sets of conditions were analyzed in the Delta:

- High inflow, represented by March 1983;
- Low inflow/high pumping, represented by October 1989; and
- Low inflow/low pumping, represented by July 1991.

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The inflows and pumping rates from DWRSIM used in DWRDSM1 for these periods and the average over the 16-year period modeled are presented in Table 3.1-2. For the high flow conditions, the total inflow is 15,224 TAF, of which approximately 33 percent is from the Sacramento River, 17 percent is from the San Joaquin River, 4 percent is from the east side streams, and 46 percent is from Yolo Bypass. The total pumping for the high flow conditions is 528 TAF and the ratio of total pumping to total inflow is 0.03. For the low inflow/high pumping conditions, the total inflow is 870 TAF, of which 90 percent is from the Sacramento River, 9 percent is from the San Joaquin River, and 1 percent is from the east side streams. The total pumping for the low inflow/high pumping conditions is 549 TAF, and the ratio of total pumping to total inflow is 0.6. For the low inflow/low pumping conditions, the total inflow is 647 TAF, of which 86 percent is from the Sacramento River, 13 percent is from the San Joaquin River, and 1 percent is from the east side streams. The total pumping for the low inflow/high pumping conditions is 136 TAF, and the pumping/inflow ratio is 0.2.

To compare the effects of the alternatives on flows, velocities, and stages in the Delta, the following locations in the Delta were selected:

1. San Joaquin River at Fourteen Mile Slough;
2. San Joaquin River at Antioch;
3. Old River at Mossdale;
4. Old River at Fabian Tract;
5. Old River at Woodward Island;
6. Old River at Franks Tract;
7. Middle River at Woodward Island;
8. Grant Line Canal;
9. Victoria Canal;
10. Delta Cross Channel;
11. Georgiana Slough;
12. Diversion to Sutter/Steamboat Sloughs;
13. Miner Slough;
14. Sacramento River at Rio Vista;
15. Mokelumne River, North Fork; and
16. Mokelumne River, South Fork.

These locations are shown by number on Figure 3.1-1 and were selected based on the following criteria:

- Located along the Sacramento River, San Joaquin River, Old River, and Middle River;
- Located where large diversions from the major rivers occur; and
- Located so that the alternatievs have potentially significant impacts on them.

The transport and fate of mass ~~injected~~ released into the Delta at various locations also was analyzed for the following flow conditions:

- High inflow/high pumping, represented by February 1979;
- Medium inflow/low pumping; represented by April 1991;
- Low inflow/high pumping, represented by October 1989; and
- Low inflow/low pumping, represented by July 1991.

These flow conditions were selected based on fish and wildlife concerns. The locations for which mass was injected into the Delta are shown in Figure 3.1-1. ~~Endpoints for~~ monitoring locations for injected mass include the following: Contra Costa Canal, export locations, Delta islands, Delta channels and waterways, or the Delta past Chipps Island. The effect of the alternatives on mass fate was evaluated by comparing the change in distribution of mass among these endpoints after 30 and 60 days.

Frequency analysis was used to evaluate net Delta outflow, central Delta outflow, X2 position, and salinity. Results are presented in percentiles for each month and for the overall data set. DWRSIM data sets, used to evaluate net Delta outflow and X2 position, consist of 73 years of monthly average values (1922 to 1994). DWRDSM1 data sets, used to evaluate central Delta outflow and salinity, consist of a 16 years subset of DWRSIM data (1976 to 1991). Results are discussed on the basis of trends rather than individual change. Trends are defined as frequent changes in any given month and in adjacent months, or seasons. The magnitude of change also is discussed when it accompanies a trend. In the following paragraphs, the methods are presented in more detail.

Figure 3.1-1 shows the locations of Delta outflow and central Delta outflow and the points where salinity is evaluated. X2 varies passes through the control section for a number of different depth conditions. Discharge (cfs) is then calculated from the product of the average velocity of the water (feet per second, fps) and the cross-sectional area (square feet) of the stream through which the water passes.

The velocity of water in a stream is not uniform. Discharge measurement is accomplished by measuring the velocity in many small vertical segments of a stream cross section, calculating the average velocity in the segment and multiplying by the area of the segment to get discharge. The total discharge in the cross section is then calculated as the sum of the segment discharges.

Discharge measurements provide a means of back-calculating the average velocity of water in the stream channel if the rate of discharge is known. It has been found (Leopold and Maddock 1953) that the average velocity at a stream bears a relationship to discharge. The relationship can be described by an equation of the form $V = aQ^b$, where V is the cross-section average velocity (fps), Q is the rate of discharge (cfs), and a and b are constants that depend on the geometry of the stream. Similar equations can be used to describe other hydraulic parameters, such as stream depth, width, and sediment load as a function of discharge. The equation for depth (D) as a function of discharge is given by $D = cQ^e$, where c and e are constants. The equation for stream width (W) as a function of discharge is given by $W = fQ^g$, where f and g are constants.

Extremes in discharge can cause erosion and sedimentation that can alter the geometry of an alluvial stream channel. Therefore, even though based on recent measurements relating hydraulic variables of velocity, depth, stream width, and sediment load to discharge, the resulting empirical relationships derived from the data are only expected to approximate actual conditions. Although more complex equations have been developed to describe some of these relationships, the equations above were used in this analysis because they provide a convenient method of estimating the velocity, depth, stream width, and sediment load from empirical data. The constants in these equations were determined by finding the equation that best fit the measured data at each gaging station used in the analysis. The constants used in the analysis are presented in Table 3.2-2.

3.2.1 Regional Analysis

After using the simulated monthly average discharge data from the DWRSIM runs to obtain the corresponding hydraulic parameters, the differences between alternative configurations were evaluated in several ways. For the regional analysis, the minimum, maximum, and average flow discharge, mean channel velocity, channel depth and channel width were calculated by month for the 72-year simulation period. The data were evaluated for each of the locations shown in Table 3.2-1, for both high and low flow conditions. The month with the highest average discharge for existing conditions was selected to represent high flows, which, for both rivers, is the month of February. The month with the lowest average discharge for existing conditions was selected to represent low flows, which is the month of August for the Sacramento River and the month of September for the San Joaquin River. For the San Joaquin River and Middle River near Upper Roberts Island.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the scour velocity of three fps at all locations within the Delta. Average velocities in the Delta for high flow conditions are generally below the scour velocity of three fps, except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter sloughs, Steamboat Slough, San Joaquin River at Upper Roberts Island, and Old River at Mossdale all have average velocities higher than three fps. However, the San Joaquin River at Upper Roberts Island has average velocities above three fps in less than six percent of the months modeled, the diversion to Steamboat and Sutter sloughs and Steamboat Slough in less than 10 percent of the months modeled, and the Sacramento River at Hood and Old River at Mossdale in less than 16 percent of the months modeled. This is generally consistent with the No Action Alternative.

again, avg velocity is only an index of scour potential. The model output is cross-section avg velocity

The hydrodynamic effects of Configuration 2A will be the same as presented above, except that Configuration 2A does not include CVP-SWP improvements. The main hydrodynamic effect of the CVP-SWP improvements is that the source of water for the Tracy Pumping Plant may be the Clifton Court Forebay instead of Old River.

The modeling results for Configuration 2B presented above do not include the storage components of this alternative. Adding storage to the system decreases the inflow from the Sacramento River on the order of 20 percent for low flow conditions. Thus, flows in the north Delta may be reduced on the order of 15 percent. In general, adding storage to the system may affect the timing of flows, depending on operational criteria. The ranges of flows and velocities experienced within any given year should not change substantially. Storage components combined with real time monitoring and adaptive management will improve management of Delta flows and velocities.

Configuration 2C

Configuration 2C involves three isolated intakes in the Delta and has not currently been modeled to determine the hydrodynamic effects on the Delta. Since Configuration 2C does not have any geometry changes to the north Delta, there should be no hydrodynamic effects in the north Delta. Hydrodynamic effects are likely to be localized to the area of the proposed intakes—Rock Slough, the San Joaquin River near Turner Cut, and the San Joaquin River near Lathrop. The intakes will allow operational flexibility, and the operating criteria will control the impacts to the Delta.

Configuration 2D

Configuration 2D improves circulation of flow and reduces reverse flows in the Delta via a Mokelumne River Floodway, East and South Delta habitats, and a 10,000-cfs Hood Intake. Average tidal flows, velocities, and stages throughout the Delta, based on DWRDSM1 modeling, are shown in Figures 5.2-12 through 5.2-14 for the high flow, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

During high flow conditions, differences in average flows between Configuration 2D and the No Action Alternative are generally small, except in locations where channel diverted to the Hood intake and subsequently travels down the Mokelumne River. In the south Delta, similar to the No Action Alternative, about 80 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale and 20 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately five percent is diverted down Middle River, 60 percent is carried by the Grant Line Canal, and five percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants. The ratio of flow in Old River to flow in Middle River (about 2.3) is higher due to setback levees. Similar to the No Action Alternative, most of the water in the central Delta flows west. Central Delta water enters Old and Middle River channels at their mouths and through Turner, Empire, and Columbia Cuts, which connect the upper San Joaquin River with Middle River. False River and the San Joaquin River carry water west while Dutch Slough conveys water into the Delta.

In most of the Delta, there are no substantial differences in velocities or stages between Configuration 2D and the No Action Alternative. However, in locations with setback levees, the velocity decreased and minimum stages increased. In Old River and the South Fork of the Mokelumne River, the velocities decreased by up to a factor of 4 and the minimum stages almost doubled in the channels with setback levees. Also, in areas near flow control structures, changes in velocities and stages were observed. During low inflow/high pumping conditions, the flow barriers were operating and the velocity in the San Joaquin River near Upper Roberts Island increased while the velocities in Grant Line Canal and Old River at Fabian Tract decreased substantially. A slower velocity will decrease sediment transport and increase sedimentation in the channel.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the scour velocity of 3 fps at all locations within the Delta. Average velocities in the Delta ~~for high~~ flow conditions ~~are~~ generally below the scour velocity of 3 fps except on the outskirts. ~~The Sacramento River at~~ Hood, diversion to Steamboat/Sutter Sloughs, Steamboat Slough, San Joaquin River at Upper Roberts Island, Old River at Mossdale, and the Grant Line Canal all have average velocities higher than 3 fps. However, Grant Line Canal has an average velocity above 3 fps in less than 1 percent of the months modeled, the San Joaquin River at Upper Roberts Island in less than 6 percent of the months modeled, the Diversion to Steamboat and Sutter Sloughs and Steamboat Slough in less than 10 percent of the months modeled, and the Sacramento River at Hood and Old River at Mossdale in less than 17 percent of the months modeled. This is generally consistent with the No Action Alternative.

The modeling results for Configuration 2D presented above do not include the storage components of this alternative. Adding storage to the system decreases the inflow from the Sacramento River on the order of 15 percent for low flow conditions. Thus, flows in the north Delta may be reduced on the order of 10 percent. The distribution of mass, however, should not change substantially with additional storage. In general, adding storage to the system may affect the timing of flows, depending upon operational criteria. The with Middle River. Dutch Slough and False River carry water into the Delta, while the San Joaquin River carries water westward.

For low flow/low pumping conditions, the results in the north Delta are similar to the low inflow/high pumping conditions but less extreme due to the reduced demand at the pumps. For low inflow/low pumping conditions, less of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs (10 percent) and the Delta Cross Channel (15 percent), and more flow is diverted to Georgiana Slough (60 percent). In the south Delta, similar to the No Action Alternative, about 80 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale and 20 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately five percent is diverted down Middle River, 55 percent is carried by the Grant Line Canal, and five percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants. The ratio of flow in Old River to flow in Middle River (about 2) is increased. Similar to the No Action Alternative, most of the water in the central Delta flows west. Central Delta water enters Old River and Middle River channels at their mouths and through Turner, Empire, and Columbia cuts, which connect the upper San Joaquin River with Middle River. False River and the San Joaquin River carry water west, while Dutch Slough moves water into the Delta.

There are no substantial differences in velocities or stages between Configuration 2E and the No Action Alternative, except in the channels with setback levees or nearby habitats. In Old River and the South Fork of the Mokelumne River, the velocities decreased by up to a factor of four in the channels with setback levees. A slower velocity will decrease sediment transport and will increase sedimentation in the channel. Minimum stages in channels with setback levees increased by almost a factor of two. Also, in Georgiana Slough at high flow conditions the stage is considerably less for Configuration 2E than for the No Action Alternative. Velocities and stages also changed in the areas near flow control structures while they were operating. During low inflow/high pumping conditions, the velocity in the San Joaquin River near Upper Roberts Island increased, while the velocities in Grant Line Canal and Old River at Fabian Tract decreased substantially.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the scour velocity of three fps at all locations within the Delta. Average velocities in the Delta for high flow conditions are generally below the scour velocity of three fps, except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter sloughs, Steamboat Slough, Georgiana Slough, San Joaquin River at Upper Roberts Island, and Old River at Mossdale all have average velocities higher than three fps. However, the San Joaquin River at Upper Roberts Island, Georgiana Slough, the Diversion to Steamboat and Sutter sloughs, and Steamboat Slough have average velocities of less than three fps in less than seven percent of the months modeled and the Sacramento River at Hood and Old River at Mossdale in less than 17 percent of the months modeled. This is generally consistent with the No Action Alternative.